Cost-effectiveness analysis and policy choices: investing in health systems

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The role of health systems infrastructure in studies of cost-effectiveness analysis and health resource allocation is discussed, and previous health sector cost-effectiveness analyses are cited. Two substantial difficulties concerning the nature of health system costs and the policy choices are presented. First, the issue of health system infrastructure can be addressed by use of computer models such as the Health Resource Allocation Model (HRAM) developed at Harvard, which integrates cost-effectiveness and burden of disease data. It was found that a model which allows for expansion in health infrastructure yields nearly 40% more total DALYs for a hypothetical sub-Saharan African country than a model which neglects infrastructure expansion. Widespread use of cost-effectiveness databases for resource allocations in the health sector will require that cost-effectiveness analyses shift from reporting costs to reporting production functions. Second, three distinct policy questions can be treated using these tools, each necessitating its own inputs and constraints: allocations when given a fixed budget and health infrastructure, or when given resources for marginal expansion, or when given a politically constrained situation of expanding resources. Confusion concerning which question is being addressed must be avoided through development of a consistent and rigorous approach to using cost-effectiveness data for informing resource allocations.

Introduction

Cost-effectiveness analysis of health sector interventions was first applied in the 1960s based on methods developed to analyse military investments (*1*). Since 1970, the number of published studies using cost-effectiveness analysis has been steadily rising, reflecting a growing concern for the appropriate use of scarce health sector resources (*2*). Initially, most cost-effectiveness studies reported results using indicators such as the cost per case diagnosed and treated of a particular disease or the cost per fully immunized child. These studies using outcome or benefit measures that are very disease or context specific have been gradually replaced by studies using more general measures of health outcome. With more widespread reporting of results in terms of costs per quality-adjusted life year (QALY) or other general health measure, comparisons of the cost-effectiveness of interventions targeting different health problems have become possible. League tables of the cost-effectiveness of different interventions are a natural consequence (*3–8*).

Two landmark policy analyses have provided an impetus to using cost-effectiveness to compare a wide range of health interventions. These exercises provide enough information so that cost-effectiveness analysis for the first time can be used to inform resource allocations across the entire health sector. First, the Oregon Health Services Commission (*9–18*) examined 714 condition-treatment pairs (called interventions in the rest of the following discussion) and calculated the cost per QALY. The valuation of outcomes from medical intervention and the rankings from cost-effectiveness analysis were then subject to extensive public review through a series of town meetings. The rank list of interventions from this process can then be used for selecting the interventions that Medicaid will finance in the State, which plans to fund (in order of the rank list) each intervention maximally until the budget runs out. This sectoral application of cost-effectiveness is now being implemented (*18*). The second major policy review was the Health Sector Priorities Review undertaken by the World Bank from 1987 to 1993 (*7*). Twenty-six major health problems of developing countries were reviewed by teams of economists, public health specialists and epidemiologists. The cost-effectiveness of more than 50 specific health interventions were evaluated using a standard methodology for costs

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and benefits.[a] These databases provide useful information on cost-effectiveness which will help determine resource allocations across the entire health sector.

Building largely on the Health Sector Priorities Review, the World Bank has promoted in the *World development report 1993: investing in health* (WDR) the concept of using cost-effectiveness of health sector interventions and the burden of disease of health problems to develop essential packages of clinical and preventive care (*23*). The WDR also proposes that cost-effectiveness analysis be used to determine the package of services covered by insurance schemes and to inform health research priorities. In this issue of the *Bulletin*, Bobadilla et al. (*24*) provide details on the method and rationale for selection and of interventions and their quantities in the proposed package. In brief, estimates of the current burden of disease are combined with a cost-effectiveness rank list of interventions, to derive packages of services that, for a given budget, will purchase the largest improvement in health as measured by DALYs (disability-adjusted life years). Given the considerable attention garnered by the WDR, it is important to examine carefully the implications of this new and more extensive application of cost-effectiveness analysis.

Limitations of sectoral cost-effectiveness

In recent years, the theoretical basis for using cost-effectiveness analysis to guide health sector resource allocations has been discussed: the validity of DALY or QALY maximization as a goal for the health sector (*25–30*), the nature of individual preferences for health states and how these preferences are incorporated into QALYs (*31–35*), the importance of marginal costs that change as a function of output (*36, 37*), the effect of intervention-specific fixed costs (*36, 38*), and the sensitivity of conclusions to abstract concepts such as discounting (*39–51*). These technical issues are important and likely to be vigorously debated for many years but probably do not have a profound effect on the sectoral application of cost-effectiveness to policy choice, although further research may indicate important modifications and refinements are needed in the methods.

Two more general and potentially important criticisms are concerned with the focus of cost-effectiveness analysis. First, cost-effectiveness analysis of health interventions, which are more often than not disease specific, tends to neglect the role of the health system in delivering these interventions. There are no explicit analyses of the cost-effectiveness of improving the physical or human infrastructure of the health system, which provide for direct comparisons between investing in the delivery system and purchasing more specific interventions delivered by the health system. Some may be concerned that the intervention focus of cost-effectiveness analysis may shift the focus of policy debate from who delivers health services to satisfying specific targets or goals for particular activities. In the extreme, some accuse cost-effectiveness analysis of fostering a vertical approach to disease control as opposed to the horizontal approach embodied in the primary health care movement. Second, there is a potential for considerable confusion, including in the WDR, on the policy choice that should be informed by cost-effectiveness analysis. For example, should cost-effectiveness analysis be used to suggest the reallocation of resources between programmes that will lead to the greatest improvement in health or should it only be used to suggest how marginal increases in health sector resources could best be allocated to improve health?

In this paper, we present in brief a proposed method by which the cost-effectiveness of investing in the physical and human infrastructure of the health system can be evaluated. A resource allocation model, the technical details of which are described elsewhere (*36*), is illustrated with an application to sub-Saharan Africa. The model is then used to address the second issue of the range of policy questions that can be addressed with cost-effectiveness analysis. Finally, some implications for future cost-effectiveness studies are highlighted.

Cost-effectiveness of investing in the health system

The accepted standard for reporting the results of cost-effectiveness studies in the literature and unpublished reports is to provide information on the average cost per unit of health output (such as a DALY) at one level of production. Average cost equals the sum of general or infrastructure fixed costs, programme-specific fixed costs, and variable costs divided by total output. Arbitrary rules are promulgated to allocate the general infrastructure fixed costs, such as the costs of hospitals and health centres to specific interventions undertaken in those facilities. These arbitrary divisions of joint production costs are usually based on some proxy measure of activity, such as staff hours, bed-days, or square-feet occupied. The treatment of the costs of maintain-

[a] To make the results of the Health Sector Priorities Review consistent with the Global Burden of Disease, benefits were measured using disability-adjusted life years. See Murray et al. (*19–22*) for details of the method of calculating benefits.

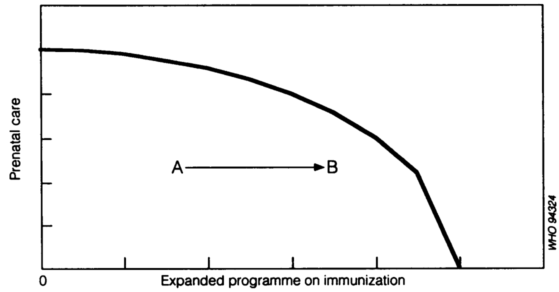
ing the physical and human infrastructure of the health system in this arbitrary manner leads to two major problems with the cost-effectiveness approach when applied to sectoral decisions.

First, the average cost-list approach used in the WDR (*23*) ignores existing infrastructure and implicitly assumes that hospitals and health centres can be built in infinitely divisible quantities.[b] The average cost of an intervention includes a component due to the general fixed costs divided by the volume of output at the time of the assessment. Allocating resources according to average unit costs implies that fractions of facilities, e.g., 2% of a health centre, can be built as required. Concomitantly, existing facilities can be used in shares less than one while the costs for the rest of the facility are not incurred. A resource allocation based on an average cost list may include only the costs of running 45% of district hospitals, ignoring the fact that hospitals and health centres come in indivisible units. For example, the package of essential clinical services proposed by the World Bank for low-income countries does not include all the costs of maintaining and operating the existing referral and district hospitals. Even the fractional costs of facilities depend on operating each new fraction at the same level of output as was included in the analysis. Otherwise the general fixed costs divided by output, which figures in average cost, would be different.

Second, even if shares of facilities could be built or closed at will, the joint costing rules artifactually penalize interventions that are more technically efficient. Fig. 1 shows a production function for a health centre that undertakes only two activities: the expanded programme of immunization (EPI) and prenatal care. The area within the curve shows all possible combinations of the two activities, given the current staffing levels and operating budget for the health centre. The production possibilities frontier which is the curved line shows what could be achieved with maximal technical efficiency for both activities.

Many health centres operate far from the production possibilities frontier. Consider a health centre at point A in Fig. 1; joint costing rules would allocate equal shares of the health centre's overhead costs to EPI and prenatal care. Imagine a new regional manager who works to increase the efficiency of EPI such that at no extra cost to the health centre it now operates at point B. Joint costing rules would now attribute a much higher share of the overhead costs to EPI than before. Clearly, fixed costs have not increased; only productivity has increased. The joint costing approach to calculating average costs entails a very real risk of penalizing with higher estimated unit costs those programmes that are more efficient.

Fig. 1. **Production function for hypothetical health centre undertaking only two activities—prenatal care and expanded programme on immunization; misallocation of overhead costs through use of joint-costing rules.** Point A represents a typical level of output and point B the increased level achieved through improved management.



To examine investments in human and physical health infrastructure in a cost-effectiveness framework, a more sophisticated approach to resource allocation questions is required. Correa (*52*) and Torrance et al. (*38*) developed hypothetical planning models to choose health maximizing mixes of interventions under various constraints. Torrance et al. (*38*) discussed the possibility of designing a resource allocation model that would directly incorporate the limits on service delivery imposed by the current health system infrastructure and the possibility of improving the health system. At least four optimization models for the health sector applied to specific interventions that maximize a measure of health status given a budget constraint and a variety of possible interventions have been developed (*37, 53–55*). None of these applications, however, attempted to incorporate the health system into the modelling exercise.

Health Resources Allocation Model (HRAM)

In order to deal with these problems, we have developed at Harvard an optimization model for the health sector based on the burden of disease, the cost-effectiveness of available health interventions, and the available health system infrastructure. Our model has been developed in the General Algebraic Modeling System (GAMS), a computer system which facili-

[b] While the cost-effectiveness analysis methods used in developing the packages of care for the WDR do not explicitly address the health system, the WDR devotes the whole of Chapter 6 to the need for developing health systems.

tates the development of algebraic models in days, which previously took months (*56*). GAMS has been extensively used in other fields such as agriculture, education and industry to deal with complex non-linear optimization problems. Our model, HRAM, has also been designed to address technical problems related to intervention fixed costs, rising marginal costs, and regional heterogeneity. The details on the latter and the technical specifications of the model are provided elsewhere (*36*) and are not discussed in this paper in detail. The following discussion describes the general strategy used to incorporate the health system into a cost-effectiveness framework.

In order to put the appraisal of infrastructure in cost-effectiveness terms, we have defined several budget constraints that include interchangeable dollars and a series of constraints reflecting the current capacity of the health system to deliver various types of services. While there is flexibility in the design of the model to specify various types of budget constraints, we have so far included constraints for services delivered at referral hospitals, district hospitals and health centres. Given current facilities and staffing levels, the Ministry of Health begins with a constraint on the volume of services it can provide through referral hospitals, district hospitals and health centres. For referral and district hospitals, we have used bed-days as the unit of service delivery, and for health centres we have used patient-contact equivalents.

Each intervention or activity may consume referral hospital bed-days, district hospital bed-days or health centre contacts in addition to interchangeable dollars. In other words, the use of the general health system infrastructure is captured in terms of units of service rather than using arbitrary joint costing rules. Table 1 provides examples of production functions for several health interventions. In choosing an optimal allocation of health resources across activities, when the available budget of district hospital bed-days is exhausted, no further interventions using district hospitals can be bought. The same limitation would apply to referral hospital bed-days and health centre contacts. However, the government may choose to build new referral hospitals, district hospitals or health centres in order to relax the service constraint. In addition to the set of interventions included in the model, three more are added: construction and staffing of a referral hospital, district hospital or health centre. For health centres, we have also included a geographical access constraint. It is not sufficient to have an adequate total number of health centre contacts for the population; health centres must be positioned close enough to the community so that they can use them. In the simulations for sub-Saharan Africa, expanding geographical access to health centres, particularly in remote areas, is a major force driving the expansion of infrastructure in an optimal resource allocation. While not included so far, geographical access constraints could also be added for district hospitals.

At each budget level, the resource allocation model searches to see if the total output of the system in terms of DALYs avoided could be increased by using some resources to expand the health system rather than spending it on particular activities delivered with the current health infrastructure. In other words, the ability of computers to undertake repetitive calculations at high speed is used to test if the total output of the health sector in terms of DALYs would be higher or lower by improving the health system. Improvements in the health system can be undertaken in this model by building, staffing and operating new referral hospitals, district hospitals or clinics.[c] In this framework, infrastructure investments can be evaluated in terms of the increase in the number of DALYs or equivalent measure of health status.

As one purchases an intervention such as measles immunization at the point where all children are immunized, the marginal cost per DALY reaches infinity because no more health benefits are gained by expanding coverage beyond 100%. While technically correct in micro-economic jargon, it is a cumbersome approach to capturing the practical limits of each intervention. More intuitive is to constrain the purchase of each intervention by the total amount of DALYs that can be addressed with a particular intervention in a particular community. The link between the burden of disease or the total number of DALYs lost due to a particular health problem and cost-effectiveness is thus established. The example of the model, which is described below, makes use of the Global Burden of Disease study results (*19*) for sub-Saharan Africa. The estimates of the current burden of disease had to be modified to remove the impact of currently financed health interventions on the measured burden of disease.

To explore the use of such an optimization model, we have used the World Bank's Health Sector Priorities Review database on the cost-effectiveness of some 50 interventions (*7*), the same database utilized by Bobadilla et al. (*24*). Each estimate of

[c] In this version of the model, we are able to build new infrastructure and use it in the same time period. The costs of opening and operating new units of infrastructure are the annual operating fixed costs plus the equivalent annual capital cost. As the model is not a multi-period model, we do not take into account the necessary time lag between the decision to improve the physical or human infrastructure of the health system and its implementation.

Table 1: **Data for the Health Resource Allocation Model for five interventions**

Intervention	Segment[a]	Programme-specific fixed costs (US $)	Marginal cost function (US $)	Per DALY: Referral hospital (bed-days)	Per DALY: District hospital (bed-days)	Per DALY: Health centre (contacts)
ARI screening	0	40 000	24.23	0	0.20	4.00
	1		27.26			
	2		30.29			
	3		33.32			
	4		36.35			
Poliomyelitis immunization	0	60 000	9.17	0	0	5.52
	1		14.66			
	2		18.33			
	3		36.66			
	4		183.30			
School-based anti-helminthic chemoprophylaxis	0	100 000	4.79	0	0	0
	1		4.79			
	2		5.99			
	3		7.19			
	4		7.19			
Short-course chemotherapy for sputum smear-positive tuberculosis	0	53 000	1.71	0	3.85	0
	1		2.74			
	2		3.42			
	3		6.84			
	4		34.20			
Tetanus referral	0	200 000	24.08	2.29	0	0
	1		32.10			
	2		40.13			
	3		48.16			
	4		56.18			

[a] To approximate the increasing marginal cost, the nonlinear marginal cost curve for each intervention within a region is broken up into five linear segments numbered from 0 to 4.

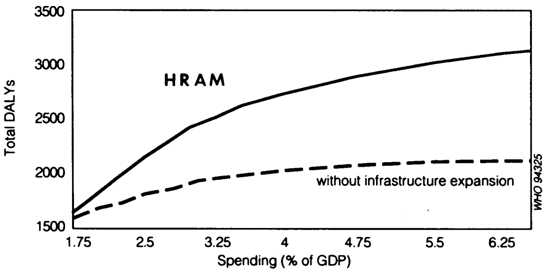
cost-effectiveness was reviewed and modified to increase the comparability across interventions. Despite our attempts to unearth details, frequently only average cost results are reported in the literature or reports on cost-effectiveness. Where necessary, expert judgement was used to develop the intervention production functions and form of the marginal cost curve, examples of which are provided in Table 1.[d]

The model was run for a hypothetical sub-Saharan African country with a population of 10 million and a GDP per capita of $340, using the regional GBD results adjusted to the total population to determine the DALY limits for each disease. A digression on the burden of disease is necessary. The results of the Global Burden of Disease study provide an estimate of the current burden of disease. Current or measured burden incorporates the impact of currently financed health interventions; for example, if measles immunization coverage is 70%, then a significant share of the burden of measles has already been avoided. There are three levels of the burden of disease relevant to this discussion of resource allocation: first, the current burden of disease; second, the burden of disease that would be present if currently financed health interventions were stopped; and third, the lowest achievable burden given a technical and allocative efficiency within a budget constraint. The resource allocation model used as an input estimated the burden in the absence of currently financed health interventions in order to calculate the lowest achievable burden of disease for a given budget.

Fig. 2 shows the expansion path for the optimal allocation of health resources to maximize DALYs averted at each budget level. For reference, current expenditure in sub-Saharan Africa excluding South Africa is US$ 14 per capita. The equivalent annual capital cost of the existing health infrastructure and the fixed operating costs of the health system are

[d] Table 1 provides a stepped marginal cost function for five interventions. For convenience, we divided non-linear marginal cost functions into five linear steps or segments which are summarized in the Table.

Fig. 2. **DALY retrieval expansion path for sub-Saharan Africa.**



US$ 3.27 per capita. This health sector production function indicates that with increasing expenditure the marginal cost of each DALY purchased increases rapidly. For all budget ranges included, the marginal cost per DALY is higher than average cost. Table 2 shows the number of new referral hospitals, district hospitals and health centres bought at three budget levels. Even at current levels of health expenditure, nearly 25% of the budget should be spent on expanding the health system. The remainder should be spent on the set of interventions listed. The Table also provides the utilization rates of the three types of facilities modelled at each budget level. Referral hospital bed-occupancy is less than 1%. The implication is that there is excess referral hospital capacity but a shortage of district hospital capacity. If closure or down-sizing of referral hospitals were politically feasible, this desirable option could be added as an additional intervention in the model.

Table 3 shows the allocation to specific interventions at three budget levels. Some highlights are worth discussing. Comparison with the WDR's $12 per capita package for low-income countries is difficult, as their package is based on a marginal increase of $12 per capita, given current expenditures. At current budget levels, the most important interventions by expenditure are screening and treatment of acute respiratory infections (ARI), malaria control, tuberculosis chemotherapy, measles immunization, oral rehydration therapy, breast-feeding, tetanus immunization, and hygiene promotion. With increases over current budget levels, the major gainers are chemotherapy for sputum smear-negative tuberculosis cases, oral rehydration therapy, malaria control and hygiene promotion.

Fig. 2 shows two expansion paths. The top line is the expansion path for the complete model. The second line is the expansion path when the options of adding infrastructure are removed from the model. Simple inspection shows that expanding the infrastructure is a tremendously important component of health improvement. At current expenditure levels in sub-Saharan Africa, expanding the health system produces nearly 40% more total DALYs.

Policy choice and sectoral cost-effectiveness

Having illustrated a model that incorporates health system investment choice into a cost-effectiveness framework, we can return to the nature of policy questions that can be treated with these analytical tools. Three distinct policy questions using burden of disease and cost-effectiveness results can be framed.

(1) *Ground-zero.* Given a fixed budget and health infrastructure, how can non-fixed resources be spent so as to maximally reduce the burden of disease?

(2) *Marginal expansion.* Given an existing health infrastructure and a set of currently financed activities, none of which can be changed, how best can marginal increases in the health sector resources be spent so as to maximally reduce the burden of disease?

(3) *Politically constrained ground-zero.* Given an existing health infrastructure, for political or other reasons there may be a set of services or activities that are deemed to be 'protected' from changes in budget and a set of other services or activities that could be expanded or contracted. For a fixed health sector budget, how can health resources be reallocated to maximally reduce the burden of disease without reducing the resources allocated to 'protected' activities?

Table 2: **Infrastructure expansion and rising budget levels**

	At 3% of GDP		At 4% of GDP		At 5% of GDP	
Facility type	Additional facilities	Utilization rate (%)	Additional facilities	Utilization rate (%)	Additional facilities	Utilization rate (%)
Referral hospital	0	0	0	0	0	0.61
District hospital	41	99	47	100	53	98
Clinic	411	56	53	64	578	74

Table 3: **Allocations to specific interventions at varying health budget levels for a hypothetical sub-Saharan African country**[a]

Intervention	At 3.0% of GDP Spending ('000 $)	At 3.0% of GDP DALYS ('000 $)	At 4.0% of GDP Spending ('000 $)	At 4.0% of GDP DALYS ('000 $)	At 5.0% of GDP Spending ('000 $)	At 5.0% of GDP DALYS ('000 $)
Fixed infrastructure[b]	32 697		32 699		32 698	
ARI screening and referral	6 879	233	11 107	277	11 107	277
Oral rehydration therapy	789	12	4 831	53	15 661	123
BCG added to DPT	920	71	1 783	80	2 291	84
Hepatitis B immunization	391	8	505	9	505	9
Iodination of salt or water	249	32	249	32	249	32
Measles immunization	4 986	272	7 686	298	12 545	324
Poliomyelitis immunization	907	30	1 232	33	1 503	34
Semiannual vitamin-A dose for children 0–5 years	577	38	881	41	881	41
Tetanus immunization	1 651	213	2 042	222	2 042	222
Breast-feeding promotion w/education or hospital routine for diarrhoeal diseases	2 564	74	2 755	77	2 755	77
Improved weaning practices from education	1 526	46	1 526	46	1 526	46
Oral iron supplementation during pregnancy	70	1	70	1	70	1
Chlamydia treatment w/antibiotics	107	6	107	6	107	6
Gonorrhoea treatment w/antibiotics	111	9	111	9	111	9
Syphilis treatment w/antibiotics	147	156	147	156	147	156
HIV blood screening	911	39	962	40	962	40
Annual breast examinations	0	0	0	0	312	1
Antibiotics for rheumatic heart disease	0	0	388	3	722	5
Cataract surgery	860	9	935	10	935	10
CVD preventive programme	0	0	0	0	287	2
Improved domestic and personal hygiene	0	0	5 306	47	9 658	72
Injected insulin and health education for IDDM[c]	0	0	0	0	231	0
Leprosy multidrug clinic	537	6	541	7	541	7
Low-cost management of acute MI[c]	0	0	0	0	780	3
Pap smear at 5-year intervals	246	1	227	2	422	2
Pneumococcal vaccine	884	16	2 543	32	3206	36
Schizophrenia	248	3	331	3	331	3
School-based anti-helminthic chemoprophylaxis	597	12	597	12	597	12
Short-course chemotherapy for sputum-negative patients	6 688	372	10 208	415	14 120	443
Short-course chemotherapy for sputum-positive patients	3 498	453	5 018	484	5 218	487
Sugar or salt fortified with iron	124	19	124	19	124	19
Tetanus referral case management	0	0	0	0	1 176	3
Vector control for malaria	12 123	304	16 587	348	18 942	364
Added infrastructure	20 713		24 502		27 238	
Total costs ('000 $)	102 000	2 435	136 000	2 762	170 000	2 950
Total cost per capita ($)	10.20		13.60		17.00	

[a] Population is assumed to be 10 million and GDP per capita $340.
[b] Fixed infrastructure reports the costs of construction, maintenance and staffing of the clinics, district hospitals and referral hospitals, which are assumed to have been constructed previously. Assumptions are based on infrastructure data for sub-Saharan African countries.
[c] IDDM: insulin-dependent diabetes mellitus. MI: myocardial infarction.

All three and combinations of (2) and (3) can be addressed using the burden of disease and cost-effectiveness information, as described above for sub-Saharan Africa. The inputs to the process, however, to answer each of these questions will be different. Table 4 shows that the budget constraint on the purchase of interventions is fixed at the current level to answer questions (1) and (3), while for the second question there is a marginal increase in the budget available to buy further interventions.

Table 4: **Setting health sector priorities: different inputs to answer different policy questions**

	Inputs to optimization or packaging		
	Budget	Burden	Health system
1. Ground-zero	Current budget minus fixed cost of operating current health infrastructure	Burden in absence of currently financed health interventions	Total available capacity
2. Marginal expansion	Marginal increase in budget	Current burden	Unused capacity
3. Politically constrained ground-zero	Current budget minus fixed cost of operating health infrastructure and cost of protected activity	For protected, current burden For remainder, burden in absence of currently financed health interventions	Total capacity, less capacity used for protected services

The burden of disease estimates that should be used either in HRAM or in the World Bank packaging exercise will be different for the three questions. The first question, which can be labelled the ground-zero exercise, was the one addressed by the HRAM applied to sub-Saharan Africa. The burden of disease in the absence of currently financed interventions is the required input. To allocate marginal increases in resources, maintaining currently financed activities, the currently observed burden of disease is the appropriate input. Finally, to answer the third question, we would want to use the current burden of disease for those conditions affected by currently financed and protected activities and the burden of disease in the absence of currently financed activities for those activities that are not protected.

Finally, the approach to the infrastructure constraints would also be different for the three questions. The ground-zero exercise would use total available capacity at each level of the health system as the constraint on service delivery with the option for building new infrastructure. The input to the marginal budget exercise would be the unused capacity at each level with the option of building new infrastructure. The politically constrained exercise would use total capacity at each level minus the capacity used to deliver 'protected' services.

In the WDR, the World Bank proposes a package of essential public health and clinical services that would cost $12 in a low-income country. This package is meant to be a marginal package of expenditure and health gain on top of currently financed activities. Some confusion is generated when the World Bank states, "In fact, in the poorest countries total current public spending of $6 per person is about $6 short of the cost of the package. Total per capita spending, including private spending, is about $14, about the same as the proposed package." (*23*, page 67). The package, however, has been described at several junctures as addressing the marginal burden of disease and has been calculated using the current burden, not the burden in the absence of currently financed activities.[e] In other words, by the nature of its calculation, the World Bank package is a marginal package on top of current expenditure. Paying for the package in a low-income country is not a question of resource reallocation but a question of increasing health expenditure by $12 per capita or a doubling of total health sector expenditure in a low-income country; if the increase was to come entirely from the public sector it would entail a tripling of publicly financed health expenditure. Potential confusion around the policy question that is being asked and the appropriate method of calculation by the World Bank highlights the importance of developing a consistent and internally rigorous approach to using cost-effectiveness for informing sectoral resource allocation questions.

Implications

The cost-effectiveness of interventions, the burden of disease, and information on the human and physical infrastructure in a health system can be combined to answer a host of resource allocation questions including variations of protected expenditures and marginal budget increases. Using a computer program like the one illustrated here, investments in the health system can be directly compared with expanding resources for particular interventions for a given level of the health system. The preliminary work presented on such models can easily be developed to incorporate other investments in health system quality or coverage. Investments in health information systems or training can be included as long

[e] The method used to calculate the package is different for different interventions. Some of the package is based on a cost per person receiving a service and an estimate of the desired coverage of the service so that this is closer to the ground-zero analysis. For others, including most of the clinical services, the package is estimated, based on the current burden of disease and the cost per DALY averted.

as the chain of causation between these investments and improvement in health through the delivery of specific health interventions can be traced. More sophisticated versions of such a computer program could take into account the delay between the decision to improve the health system and the completion of new construction or training. A multi-period model would also allow for incorporating expected changes in the burden of disease due to demographic and epidemiological changes (*57, 58*).

If more widespread use of cost-effectiveness databases to inform health sector resource allocation is intended, then it will be important to alter the standards of reporting cost-effectiveness studies in the literature. Frequently studies report only an average cost per unit of service delivered or health benefit such as a DALY. Details on the component costs are often not provided. In order to examine the cost-effectiveness of investing in the health system, we must shift to reporting the different resources used in providing a health intervention rather than costs. Table 1 illustrates crude forms of such resource use profiles where the component inputs such as bed-days, clinic contacts, or outreach workers are denominated. More detailed resource use profiles could be provided outlining specific inputs and the necessary quality of the inputs such as nursing or surgeons' time, etc. There is an urgent need to develop a simple but useful categorization of the inputs to health service production that provides sufficient detail for sectoral analysis.

Another major benefit from a shift to reporting production functions would be to increase the transferability of cost-effectiveness results from one environment to another. In the WDR, studies on the cost-effectiveness of a programme in the United Republic of Tanzania are directly compared with results of studies in Brazil where the same input such as nursing time can be ten times more expensive in dollar terms; nevertheless, the World Bank is well aware of these limitations and the urgent need to refine methods to transfer cost-effectiveness results from one context to another. Such comparisons obscure the real use of resources for health programmes which would be transparent if resource use is reported directly. We hope that the World Bank and the World Health Organization will take the lead in developing a standard approach to reporting health intervention resource use profiles and ultimately production functions.

In this paper, we have argued that cost-effectiveness results, information on the burden of disease, and details on the available health system resources can be combined to provide useful insights into a wide range of questions on allocation of health sector resources. All these questions, however, are complicated and require at present the assistance of sophisticated computer algorithms to define preferable patterns of resource allocation. Given the early stage of development of this sectoral application of cost-effectiveness, it appears that computer programs, such as HRAM, will remain an essential adjunct to policy analysis. Ultimately, as these methods are tested in a range of countries, simpler decision rules may be developed that will allow for more rapid application of the cost-effectiveness and disease burden results to questions of resource allocation.

Despite the challenges raised in this paper, the method proposed by the WDR and others remains a much better alternative to current practice. We should not let the perfect be the enemy of the good. The World Bank's Health Sector Priorities Review and the 1993 WDR have advanced technical analysis of health policy choices in developing countries by years if not decades. On the other hand, we must always remain cognizant of the fact that technical analysis of health sector priorities using the burden of disease, the cost-effectiveness of interventions, and the available resources is only one input to the policy process and is not intended to be a rigid prescription for all health system ailments.

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Résumé

Investigation du secteur de santé: analyse coût-efficacité et choix politiques

Les études actuelles sur l'affectation des ressources en fonction du rapport coût-efficacité — notamment l'*Oregon State plan* et le *Rapport sur le développement dans le monde 1993* de la Banque mondiale — prêtent le flanc à deux critiques importantes. Tout d'abord, les analyses coût-efficacité tendent à négliger le rôle des infrastructures de santé. Ensuite, se pose le problème des choix politiques qui devraient être documentés par une analyse coût-efficacité de l'affectation des ressources.

En premier lieu, les études qui négligent le rôle de l'infrastructure dans l'affectation des ressources d'après leur coût-efficacité supposent implicitement que l'infrastructure physique est infiniment divisible. La méthode utilisant la liste des coûts moyens (comme celle utilisée dans le rap-

port de la Banque mondiale) suppose que des fractions des installations, 2% d'un hôpital de district par exemple, peuvent être construites conformément aux normes. Une nouvelle difficulté intervient avec les effets indésirables de l'établissement conjoint des coûts.

Cet effet infrastructure peut être corrigé en utilisant un modèle informatisé tel que le *Harvard Health Resources Allocation Model* (HHRAM) qui, comme dans le rapport de la Banque mondiale, intègre le rapport coût-efficacité et le poids de la morbidité. Le HHRAM a été appliqué à un pays d'Afrique subsaharienne fictif, ayant une population de 10 millions d'habitants et un PIB par habitant de US$ 340; ce modèle, qui tient compte de l'expansion des infrastructures de santé dans l'affectation des ressources, donne un nombre total de DALY supérieur de 40% à ce que donne un modèle négligeant l'infrastructure. Au niveau des budgets actuels — qui pour l'Afrique subsaharienne, à l'exclusion de l'Afrique du Sud, est de US$ 14 par habitant — les interventions les plus importantes compte tenu des dépenses sont le dépistage et le traitement des infections respiratoires aiguës, la lutte antipaludique, la chimiothérapie antituberculeuse, la vaccination antirougeoleuse, la réhydratation orale, l'allaitement au sein, la vaccination antitétanique et l'amélioration de l'hygiène.

Le second point est que l'analyse coût-efficacité de l'affectation des ressources permet de traiter trois questions de politique distinctes, chacune avec ses propres contraintes budgétaires et infrastructurelles et ses propres estimations du poids de la morbidité. 1) Affectation à partir du niveau zéro: étant donnés un budget fixe et une infrastructure de santé, comment des ressources non fixées peuvent-elles être dépensées de façon à diminuer au maximum le poids de la morbidité? 2) Affectation de ressources à l'expansion marginale: étant donnés une infrastructure de santé et un ensemble d'activités actuellement financées, dont aucune ne peut être modifiée, comment les augmentations marginales des ressources du secteur de santé peuvent-elles être dépensées de façon à diminuer au maximum le poids de la morbidité ? 3) Affectation au niveau zéro politiquement limitée: le budget du secteur de santé étant fixé, comment les ressources pour la santé peuvent-elles être réaffectées pour diminuer au maximum le poids de la morbidité sans diminuer les ressources affectées aux activités «protégées». Le problème de savoir quelle est la question traitée par une étude doit être évité en élaborant une méthode cohérente et rigoureuse d'utilisation du rapport coût-efficacité pour documenter l'affectation de ressources.

Une conséquence de l'analyse ci-dessus est que pour examiner le rapport coût-efficacité de l'investigation des systèmes de santé, il faut rendre compte des fonctions de production des interventions de santé plutôt que des coûts. Nous souhaitons que la Banque mondiale et l'Organisation mondiale de la Santé donnent l'exemple en mettant au point une méthode codifiée pour l'évaluation des fonctions de production des interventions de santé.

Malgré les problèmes soulevés dans cet article, la méthode proposée par le rapport de la Banque mondiale et divers auteurs reste la meilleure alternative à la pratique actuelle. Toutefois, ne pas oublier que l'analyse technique des priorités du secteur de santé ne prétend pas être une prescription rigide destinée à traiter tous les maux des systèmes de santé.

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